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Viewpoint

Intraoperative Crossover: The Well-Kept Surgical Secret to Apparent Surgical Success

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Cardiologists and patients contemplate the risk of proposed operations. Surgeons typically report outcomes on operations performed. Emergency intraoperative crossover from off- to on-pump coronary artery bypass grafting occurs uncommonly but has substantial rates of mortality and morbidity. Much of the reported perioperative benefit of off- compared with on-pump coronary artery bypass grafting is erased if data are presented by intention to treat and not by operation performed. Cardiologists and cardiac surgeons should share the responsibility for advising a patient to consent to a cardiac operation using honestly presented evidence of potential benefits and risks substantiated with information analyzed in patient-centric and not physician-centric ways. (J Am Coll Cardiol 2005;45:1529–31) © 2005 by the American College of Cardiology Foundation

One of the highest risk decisions cardiologists regularly make is to refer a patient for cardiac surgery. This decision burden was jointly shared by cardiologists and cardiac surgeons in the days when almost all cardiology trainees completed a cardiac surgical rotation, cardiologists compulsively discussed each patient considered for surgery with one or more prospective cardiac surgeons, and cardiac surgeons routinely called cardiologists to the operating room for joint deliberations if changes were needed in the operative plan. Patients still trust cardiologists to advise them about their need for a cardiac surgical procedure and by whom and how the operation should be performed. However, the time press of modern cardiology practice has understandably distanced the cardiologist from direct involvement in surgical practice and thereby lessened their qualifications to insightfully make surgical care recommendations. Increasingly, patients with known cardiac illness monitor the Internet and news media for promising treatments and often bring a bias to consultation in favor of innovation over standard cardiac surgery. Patient preference for off cardiopulmonary bypass (off-pump) approach to coronary artery bypass grafting (CABG) is a recent example in which the conjunction of patient over-enthusiasm and many cardiologists' superficial insight has led to the overvaluing of a "new and promising therapy."

Surgical tradition permits naming an operation as the one completed and not as the one undertaken initially. To protect the welfare of the patient, every simplified operation should be converted to a more standard operation when the intraoperative situation deteriorates. Conversion also helps the surgeon because later when comparisons are made between the new and standard operations, the risk incurred by attempting the new operation is assigned to the old operation cohort. Cardiac surgeons who remain sufficiently wise and nimble to begin an on-pump procedure before a patient is irretrievably dead in the operating room should experience no intraoperative deaths for off-pump coronary bypass. Intraoperative crossover is the surgical secret that permits cardiac surgeons to obscure the true early unfavorable outcomes of a new cardiac procedure, such as off-pump CABG.

Mack et al. (1) retrospectively reported outcomes for 17,401 patients undergoing CABG who were treated at four of the most experienced U.S. centers in off-pump CABG during 1999 to 2001. Off-pump CABG was used in 7,283 (42%) and 10,118 (58%) of the 17,401 patients were treated on pump. Unadjusted mortality analyzed by operation received was 1.9% in the off-pump group compared with 3.5% in the on-pump group ($p < 0.001$). Results reported by operation received after propensity matching all multivessel disease off-pump to on-pump patients showed a 2.2% off-pump CABG mortality and a 3.7% on-pump mortality ($p < 0.001$). Intraoperative crossover could not be addressed in this work because the data had only been prospectively collected on intention to treat in two of the four centers.

Against this backdrop of obscure reporting, a separate report from one of the four centers (Lenox Hill Hospital) stands out as the single most informative paper published yet comparing on- and off-pump CABG because of analyzing a defined study population of off-pump CABG by intention to treat (2). This work received my personal, "Best Cardiac Surgical Paper of 2004 Award," of the more than 1,000 cardiac surgery papers reviewed for the Year in Cardiovascular Surgery report (3). This highly experienced group in minimally invasive and off-pump CABG defined their intention to treat 1,678 consecutive patients with off-pump CABG between January 1999 and July 2002.

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Abbreviations and Acronyms

CABG = coronary artery bypass grafting
off-pump = off cardiopulmonary bypass coronary artery bypass grafting
on-pump = on cardiopulmonary bypass coronary artery bypass grafting

Preoperative, intraoperative, and postoperative information was entered prospectively into the New York State Cardiac Surgery Reporting System and used for defining a risk-adjusted mortality. Patient records were reviewed for details of intraoperative crossover. After a chest incision permitted direct inspection of the heart, 45 (2.8%) of the 1,678 patients were electively converted in a stable condition to on-pump coronary bypass. Outcomes in these 45 patients were similar to the 1,583 patients who underwent off-pump CABG. However, after beginning the off-pump CABG, 50 (3.0%) of the 1,678 patients required emergency cannulation and institution of cardiopulmonary bypass to complete the cardiac operation on-pump. Myocardial ischemia, often with hypotension, occurred in 29 (58%) of the 50 patients, and cardiac arrest occurred in 15 (30%) of the group. Cardiopulmonary bypass was required in an additional six patients because of bleeding (four patients), coronary artery air embolism (one patient), and aortic dissection (one patient).

Data in Table 1 compare postoperative outcomes in patients with and without emergency conversion. Every unfavorable outcome occurred more commonly and freedom from all complications was significantly lower and in-hospital mortality significantly higher in the 50 patients with emergency conversion. Using the New York State risk-adjusted mortality, 1.8 deaths would have been expected in the 50 emergency conversion patients, but 6 (12%) died. Moreover, 18 (36%) of the 50 emergency conversion patients died or had a major complication compared with 145 (8.1%) of the patients who received the intended CABG operation without cardiopulmonary bypass.

Medical City Dallas was the other of four centers in the Mack et al. (1) paper that separately reported off-pump CABG crossover experience from January 2000 through June 2002 (4). Intraoperative crossover occurred in 61 (1.34%) of the 4,538 patients undergoing elective CABG. Operative mortality occurred in 11 (18%) of the 61 patients requiring conversion compared with 5 (2.7%) of 183 patients selected by similarity of baseline characteristics with the conversion group from 2,894 patients treated by on-pump CABG. Because data were provided on only a representative subset of the on-pump CABG cohort, mortality cannot be retrospectively calculated by intention to treat to compare with mortality based on operation received. However, if the other three centers in the Mack et al. (1) report had a similar rate of intraoperative crossover (1.34%) and crossover mortality (18%), approximately 42 deaths would have occurred in 233 patients converted from off- to on-pump CABG in the 17,401 patient experience (1). Transferring the 42 deaths in the intraoperative crossover population from the on- to the off-pump group to analyze by intention to treat would increase the off-pump mortality from 1.9% reported for operation received to 2.4% and decrease the on-pump mortality from 3.5% for operation received to 3.2%.

Therefore, patient-based reporting of outcomes by intention to treat would be expected to erase the surgeon-based reported modest advantage of off-pump surgery suggested by summation of reports of 23 previous randomized trials comparing off- and on-pump CABG in 2,788 patients (128 patients per study) (3). Unfortunately, the occurrence of intraoperative crossover is mentioned in only a few of these articles; therefore, a proper analysis of combined data cannot be made. Moreover, a higher risk-adjusted mortality and need for more repeat revascularization with off-pump compared to on-pump CABG has been reported after three years of follow-up for 68,179 CABG patients in New York (5). These recent reports suggesting little, if any, early benefit but less long-term durability are certain to dampen the enthusiasm of cardiologists for referring patients to off-

Table 1. Postoperative Outcomes in 1,678 Patients With Planned Off-Pump CABG

Variable	Emergency Conversion to CPB (n = 50)	OPCAB Without Emergency Conversion to CPB (n = 1,628)	p Value
Freedom from all complications	64% (n = 32)	91.9% (n = 1,483)	0.0001
Stroke	6.0% (n = 3)	1.1% (n = 18)	0.02
Transmural myocardial infarction	2.0% (n = 1)	0.4% (n = 7)	NS
Deep sternal wound infection	8.0% (n = 4)	1.5% (n = 25)	0.009
Bleeding requiring reoperation	10.0% (n = 5)	2.0% (n = 32)	0.004
Sepsis	2.0% (n = 1)	1.1% (n = 18)	NS
GI bleed perforation, or infarction	4.0% (n = 2)	1.4% (n = 22)	NS
Renal failure-dialysis	6.0% (n = 3)	1.2% (n = 20)	0.028
Respiratory failure	28.0% (n = 14)	3.7% (n = 61)	0.0001
In-hospital mortality	12.0% (n = 6)	1.4% (n = 24)	0.001
Risk-adjusted mortality	4.4%	1.7%	NA

Reprinted from J Thorac Cardiovasc Surg 128, Patel NC, Patel NU, Loulmet DF, McCabe JC, Subramanian VA. Emergency conversion to cardiopulmonary bypass during attempted off-pump revascularization results in increased morbidity and mortality. 655–61; 2004, with permission from The American Association for Thoracic Surgery.

CPB = cardiopulmonary bypass; GI = gastrointestinal; NS = not significant; OPCAB = off-pump coronary artery bypass.

pump CABG in the absence of a randomized clinical trial demonstrating benefit.

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